

Parasitic attitudes

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Abstract Karttunen observes that a presupposition triggered inside an attitude ascription, can be filtered out by a seemingly inaccessible antecedent under the scope of a preceding belief ascription. This poses a major challenge for presupposition theory and the semantics of attitude ascriptions. I solve the problem by enriching the semantics of attitude ascriptions with some independently argued assumptions on the structure and interpretation of mental states. In particular, I propose a DRT-based representation of mental states with a global belief-layer and a variety of labeled attitude compartments embedded within it. Hence, desires and other non-doxastic attitudes are asymmetrically dependent on beliefs. I integrate these mental state representations into a general semantic account of attitude ascriptions which relies on the parasitic nature of non-doxastic attitudes to solve Karttunen's puzzle.

Keywords Attitude ascriptions · Belief/desire reports · Presupposition · Mental states · DRT

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1 Introduction

To capture the seemingly erratic projection behavior of presuppositions in complex sentences, Karttunen (1973) proposes a classification of embedding environments. Negation, for instance, is a *hole*: all presuppositions of a sentence φ are inherited by $\neg\varphi$. For example, *the king of France is not bald* presupposes that there is a king of France. Conditionals are *filters*: a presupposition of φ may be “canceled” when φ occurs in a configuration of the form $\psi \rightarrow \varphi$. More specifically, filtering in such a configuration occurs precisely when ψ entails a presupposition of φ . For example, *If France has a king, the king of France is bald* does not presuppose the existence of a king of France. Finally, environments that systematically cancel all presuppositions of clauses embedded within them are called *plugs*. Karttunen puts verbs of saying with clausal complements in this category. For instance, *Harry has promised Bill to introduce him to the king of France* does not presuppose that France has a king.

In the final sections of the paper Karttunen turns to attitude ascriptions. Does the presupposition that it was raining survive the embedding in (1)?

- (1) Bill {believes/hopes} that it stopped raining.

After considering some confounding factors, he cautiously suggests a positive answer and hence “it appears feasible to maintain the view that *believe* and other similar propositional attitude verbs are holes”.

Karttunen concludes the section with a discussion of the following example¹:

- (2) Bill believed that Fred had been beating his wife and he hoped that Fred would stop beating her. [Karttunen 1973, ex. (42)]

If attitude embeddings are holes, the second conjunct on its own would presuppose that Fred had been beating his wife. Clearly, (2) as a whole does not presuppose this, so it must have been filtered out. But, according to Karttunen’s own proposal, filtering in conjunctions only occurs if the first conjunct entails the presupposition of the second, which is not the case here. Karttunen thus retracts the premise, and concludes that *hope* and other attitude verbs are plugs.

But if attitude verbs are plugs, how do we explain the common intuition that presuppositions tend to escape attitude embeddings like (1) (cf. e.g. Gazdar 1979; van der Sandt 1992; Geurts 1998; Maier 2010; Romoli and Sudo 2009)? I will maintain the standard position that presuppositions tend to project out of attitude ascriptions. The puzzle therefore is how to account for the observed presupposition cancellation in (2). In my view, this problem transcends presupposition theory narrowly construed. Instead, it requires an examination of the semantics of belief and desire ascriptions in discourse (Sects. 4–5), which in turn requires an examination of the structure of mental states (Sect. 3).

The structure of the paper is as follows. In Sect. 2 I first recast Karttunen’s puzzle more precisely in modern presupposition-theoretic terms. I then critically evaluate Heim’s influential solution, pointing out where the current proposal will improve upon hers.

¹ Karttunen ascribes the observation to John Lawler.

In Sect. 3 I work out a concrete proposal for the logical representation of mental states. The framework builds on Kamp's work on the representation of attitudes in DRT (Kamp 1990). A key feature of my proposal is that non-doxastic attitudes are represented as embedded in—and hence asymmetrically dependent on—beliefs.

In Sect. 4 I turn to the interpretation of attitude ascriptions in natural language. Fitting the mental state representations developed above into a DRT account of presupposition projection and belief reports will shed new light on the classical *de re/de dicto* distinction. For attitude ascriptions other than belief, I predict a third reading, the so-called *de credito* (Yanovich 2011). On the current approach, both Karttunen's puzzle and this attested *de credito* reading are essentially linguistic manifestations of the underlying "parasitic" nature of non-doxastic attitudes.

In Sect. 5 I move from simple, single sentence ascriptions to discourses. I propose an extension of the standard resolution algorithm where partial attitude representations ascribed to the same individual may be merged into a single, more precise representation. Applied to Karttunen's puzzle, we merge a contextually established attitude ascription (Bill believing that Fred has been beating his wife) with a second attitude ascription (Bill hoping that Fred will stop beating her). Combined with the parasitic representation of desire in a mental state description, this predicts precisely the presupposition filtering that puzzled Karttunen.

2 Presupposition and propositional attitudes

In this section I reconstruct Karttunen's puzzle in modern, dynamic presupposition theory. This allows me to dismiss some potential simple solutions in Sect. 2.2. In Sect. 2.3 I challenge Heim's (1992) more promising solution.

2.1 Karttunen's puzzle

The use of the aspectual verb *stop* in an utterance of (3) triggers the presupposition that Jane has been cheating on her husband. In other words, my use of (3) is only felicitous if it is common ground between me and my audience that Jane was cheating on her husband.

- (3) Jane stopped cheating on her husband.

In dynamic semantics we formalize this as follows. Following Stalnaker (1970), dynamic discourse interpretation is modeled in terms of successive updates to the common ground, or "context". Presuppositions function as restrictions on admissible inputs for these updates. Concretely, an update of a context with (3) is only defined if that context entails or "satisfies" the proposition that Jane has a husband and has been cheating on him. If a context update is not defined the sentence is predicted to be infelicitous in that context.

Next, as Karttunen and many others have observed, attitude ascriptions usually inherit the presuppositions of their complements, i.e. (4), like (3), presupposes that Jane in fact has a husband and has been cheating on him.

- (4) Sue hopes that Jane stops cheating on her husband.

It is also very well-established that a presupposition is “canceled” when it is entailed by the relevant (global or local) context. The examples in (5) therefore do not presuppose that Jane is cheating on her husband.

- (5) a. Jane is cheating on her husband. Sue hopes Jane stops cheating on him.
- b. Jane is cheating on her husband and Sue hopes Jane stops cheating on him.
- c. If Jane is cheating on her husband, then Sue hopes Jane stops cheating on her husband.

Dynamic presupposition theory describes the cancellations in (5) as follows. Take (5a). Interpreting this mini-discourse means performing two successive updates on the context. The first update adds the information that Jane is cheating on her husband. The second update is defined iff the context entails the existence of such a cheating event. But after the first update this information is satisfied, so the second update is defined. No definedness requirement remains, so the presupposition has disappeared. A similar story involving successive updates holds for (5b–c).² Henceforth, we will focus on simple satisfaction in discourses like (5a).

The puzzle is that the presupposition also disappears in a configuration like (6) where the relevant context does not entail it:

- (6) Sue thinks Jane cheated on her husband. She hopes Jane stops cheating on him.

In this example it doesn’t follow from the first sentence that Jane cheated on her husband, so our theory predicts that the presupposition survives. But it doesn’t. The discourse as a whole is felicitous in a context where the presupposition is not satisfied, or even if it is common ground Sue is in fact mistaken about Jane’s alleged infidelity.

2.2 Initial diagnoses

Karttunen’s proposal that *hope* is a plug that simply annihilates all presuppositions is clearly an *ad hoc* solution. It correctly predicts that no presupposition survives in (6), but it goes against our intuition that presuppositions typically escape simple *hope* embeddings like (4).

Since the local context embedded under the belief operator in the first sentence clearly does satisfy the presupposition, it seems more natural to assume that somehow that local context is responsible for filtering the presupposition. But how can that be? My own answer below will start with the observation of an asymmetry between belief and hope ascriptions with respect to presupposition satisfaction. Consider the contrast in (7), involving the presupposition trigger *too* (associating with the focused element, *Sue*, marked in small caps)³:

² In dynamic semantics, (5b) is equivalent to (5a). The dynamic semantics of conditionals is more complex, but in any case, the result is that in (5c) the consequent’s presupposition is filtered because it is entailed by the antecedent.

³ The classical view, associated with Karttunen and Peters (1979), that *too* triggers a simple existential presupposition, someone other than Sue came, is famously contested by Kripke (2009). In response, Heim (1992) and van der Sandt and Geurts (2001) propose more sophisticated presuppositional analyses. In

- (7) a. John believes that Mary will come. He hopes that SUE will come too.
 b. *John hopes that Mary will come. He believes that SUE will come too.

The key assumption of my account will be that this linguistic asymmetry mirrors an underlying asymmetry in the logic of the attitudes themselves: desire and other non-doxastic attitudes are *parasitic* on belief. But before delving into the structure of attitudes, I first dismiss some other initial attempts at solving Karttunen's puzzle. Heim's (1992) analysis is discussed in a separate subsection below.

Karttunen himself already dismisses one simple solution, which, however, seems to work well for apparently similar cases of unexpected filtering in sequences of attitude ascriptions like in (8):

- (8) a. John believes that Mary used to smoke. He believes she stopped smoking last year.
 b. John hopes that Mary will come. He hopes that SUE will come too.

As before, the presupposition of the second ascription, that Mary used to smoke or that someone other than Sue will come, respectively, is not entailed by the first ascription, but intuitively it gets filtered out nonetheless. For a conjunction of ascriptions where subject and mode of attitude are kept constant,⁴ Karttunen suggests that we could read it as a single ascription at some level of logical form: *John hopes that (Mary will come and Sue will come too)*. In such a logical form, filtering is indeed predicted at the level of the embedded conjunction. However, the original example, (6), is not amenable to such a re-analysis because it involves two distinct attitudes: *x believes that φ and x hopes that ψ* is not reducible to any single statement of the form *x [attitude verb]s that φ and ψ* . It seems that the re-analysis strategy is a dead end.

Another possibility we might explore is that the observed cancellation is due to *local accommodation*. Local accommodation means that a presupposition may get added to a relevant local context to avoid infelicity. A classic example is (9), uttered in a context where the interlocutors don't know the guy they are talking about.

- (9) A: I wonder why that guy is looking so glum.
 B: Maybe his girlfriend jilted him. [Fauconnier 1994]

In this case, local accommodation of the presupposition that he has a girlfriend under the modal yields the most likely interpretation: *maybe (he has a girlfriend and his girlfriend jilted him)*.

Local accommodation appears to give the right result for the single mode sequences in (8). For instance, (8b) would get truth-conditions paraphrasable as *John hopes that*

Footnote 3 continued

Sect. 5.4 I implement a version of the Geurts & van der Sandt approach. Since the analysis of *too* is an independent issue I will just stick with the classical paraphrase for now.

⁴ As an anonymous reviewer points out, we see this type of filtering already when the attitude verbs are "similar enough" but not identical, e.g. in *believe-think* or *hope-want* sequences. In the current paper I simply ignore the finer distinctions among different doxastic attitudes/verbs and among different buletic attitudes/verbs. To properly address this issue, future research will have to take into account more detailed typologies of both attitudes and attitude ascribing verbs.

Mary will come to his party and he hopes that someone other than Sue will come to the party and that Sue will come. However, for the actual Karttunen puzzle, (6), local accommodation yields *Sue thinks Jane cheated on her husband and she hopes that Jane cheated on her husband and stopped that cheating*. On this reading it would follow,⁵ quite counterintuitively, that Sue hopes that Jane cheated on her husband.

For an additional argument against the local accommodation strategy, note that we observe Karttunen filtering with presupposition triggers that are known to resist accommodation. The example in (7a) is a case in point, as it illustrates *believe–hope* filtering with *too*, a well-known accommodation-resistant trigger (van der Sandt and Geurts 2001; Kripke 2009).

In sum, we have examined and discarded three possible explanations for the observed presupposition satisfaction in Karttunen’s example: analyzing *hope* as a plug, rewriting sequences of attitude ascriptions as a single ascription, and local accommodation. In the next section I reconstruct Heim’s solution.

2.3 Heim’s solution

In an influential paper, Heim (1992) has attempted to derive the puzzling projection behavior of presuppositions in attitude contexts from her dynamic theory of presupposition satisfaction and some independent assumptions about the logical properties of bulletic attitudes. In order to better motivate my own alternative proposal I will briefly review the main points of Heim’s analysis and point out some of its weaknesses that the current proposal will improve upon.

2.3.1 Attitude ascriptions in context change semantics

Heim’s proposal is couched in a version of her own dynamic context change semantics. A sentence φ is interpreted as an attempt to update the context C , modeled as a set of possible worlds. Saying “It’s raining” removes all worlds where it’s not currently raining from C . But such an update of C is only defined if all the (lexically triggered) presuppositions associated with the sentence are satisfied in C .

To formalize this, assume that a static, intensional semantics is given. Notation: $\llbracket \varphi \rrbracket_w$ = the truth value of φ in w ; $\llbracket \varphi \rrbracket$ = the proposition expressed by φ = the set of possible worlds in which φ is true. Further assume that with every atomic sentence φ we have associated a (possibly empty) set of sentences that constitute the presuppositions conventionally triggered by φ . Now, the rules of the dynamic semantics should tell us when an update of a context C with a sentence φ is defined, and what new context would be the result of the update. For atomic sentences we have the following Stalnaker-style update rule:

⁵ At least, this entailment holds under a straightforward Hintikka-style analysis where propositional attitudes are intensional operators, closed under logical consequence. However, as an anonymous reviewer points out, there are some well-known counterexamples to the closure of desire attitudes (cf. Heim 1992, p. 194 and references cited there). Interestingly, these counterexamples typically exploit precisely the kind of dependencies between beliefs and desires that we also see in Karttunen’s puzzle. Hence, both Heim’s solution to Karttunen’s puzzle and my own can deal with these counterexamples as well.

- (10) $C + \varphi = C \cap \llbracket \varphi \rrbracket$, if $C \subseteq \llbracket \psi \rrbracket$ for all presuppositions ψ of φ ; undefined otherwise.

Complex sentences update the contexts in two or more steps:

- (11) a. $C + \neg\varphi = C \setminus (C + \varphi)$
 b. $C + \varphi \wedge \psi = (C + \varphi) + \psi$

Other logical connectives can be defined in terms of these in the usual way, e.g. $\varphi \rightarrow \psi = \neg(\varphi \wedge \neg\psi)$.

The update semantics given by (10) and (11) accounts for standard examples of presupposition projection. For instance, let's assume that the atomic sentence *my brother is bald* presupposes *I have a brother*. According to (11a) an update with *my brother is not bald*, $C + \neg(\text{my brother is bald})$, requires that we compute $C + (\text{my brother is bald})$, and hence is only defined if that atomic update is defined. If we identify the presuppositions of a complex sentence with its definedness conditions, through (12b), it follows that the dynamic negation defined in (11a) does not affect the presuppositions of an embedded constituent, i.e. negation functions as a hole.

- (12) a. C satisfies φ iff $C + \varphi = C$
 b. φ presupposes ψ iff for all C where $C + \varphi$ is defined, C satisfies ψ

The semantics also correctly predicts filtering in conjunctions and conditionals. For instance, $C + (I \text{ have a brother} \wedge \text{my brother is bald})$ is defined whenever (i) $C + (I \text{ have a brother})$, call that set C' , is defined, and (ii) $C' + (\text{my brother is bald})$ is defined. The former is an atomic update without presuppositional expressions, so C' is always defined and contains only worlds where my brother is bald. The latter update does involve a presupposition, but, given the first update, it is satisfied in its context C' . So the whole two-step update is always defined, meaning that the presupposition of the second conjunct has been canceled.

Now we have to add attitude ascriptions. Heim's starting point is the static Hintikka (1969) semantics of belief as a modal operator, i.e. x believes that φ is true in w iff φ is true in all of x 's doxastic alternatives ($Dox(x, w)$ denotes the set of worlds compatible with what x believes in w).

- (13) $\llbracket \text{BEL}_a \varphi \rrbracket_w = 1$ iff $Dox(\llbracket a \rrbracket_w, w) \subseteq \llbracket \varphi \rrbracket$

To make this dynamic, we should treat an update with a belief ascription as removing worlds from C . Replacing the static notion of a proposition as a set of worlds with the dynamic notion of satisfaction by a set of worlds, Heim proposes the following rule:

- (14) $C + \text{BEL}_a \varphi = \{w \in C \mid \text{Dox}(\llbracket a \rrbracket_w, w) \text{ satisfies } \varphi\}$

This update is defined whenever the set of the agent's doxastic alternatives satisfies φ 's presuppositions. Reformulated in terms of projection: if φ presupposes ψ then $\text{BEL}_a \varphi$ presupposes $\text{BEL}_a \psi$.

The rule in (14) accounts for filtering in *believe–believe* sequences like (8a). Extending (14) to hope ascriptions by replacing *Dox* with *Bul*, the set of an agent's buletic alternatives, we derive: if φ presupposes ψ , then $\text{HOPE}_a \varphi$ presupposes $\text{HOPE}_a \psi$.

This would cover filtering in *hope–hope* sequences like (8b), but not in Karttunen’s *believe–hope* sequence, (6). In fact, the presupposition we would then generate for the second sentence in the Karttunen puzzle is that Sue hopes that Jane used to cheat on her husband, which is already highly counterintuitive in its own right.

To remedy this, Heim replaces the underlying Hintikka semantics of desire with a more sophisticated analysis in terms of a preference ranking on (sets of) possible worlds, inspired by Stalnaker (1984). Instead of *hope* Heim analyzes *want*: wanting that φ means that you prefer φ -worlds to not- φ worlds. That is, x *wants that* φ is true iff x prefers any doxastic alternative where φ holds to any other doxastic alternative where it doesn’t. Let $X \prec_{w,a} Y$ abbreviate that a in w prefers all worlds in X to any world in Y .

$$(15) \quad \llbracket \text{WANT}_a \varphi \rrbracket_w = 1 \text{ iff } (\text{Dox}(\llbracket a \rrbracket_w, w) \cap \llbracket \varphi \rrbracket) \prec_{\llbracket a \rrbracket_w, w} (\text{Dox}(\llbracket a \rrbracket_w, w) \cap \llbracket \neg \varphi \rrbracket)$$

In order to avoid a number of undesirable consequences (like closure under logical consequence), Heim proposes some further refinements to (15). Later on, she also proposes some modifications to capture counterfactual and factive desire predicates (*wish* and *be glad*, respectively).⁶ Since all these issues are independent of Karttunen’s presupposition puzzle, I will stick with (15) and ignore the differences between hoping, wanting and other desire attitudes.

The static semantics in (15) translates straightforwardly into the following dynamic update rule:

$$(16) \quad C + \text{WANT}_a \varphi = \{w \in C \mid (\text{Dox}(\llbracket a \rrbracket_w, w) + \varphi) \prec_{\llbracket a \rrbracket_w, w} (\text{Dox}(\llbracket a \rrbracket_w, w) + \neg \varphi)\}$$

Looking at when the updates on the right hand side of the equation are defined we can prove the following:

$$(17) \quad \text{if } \varphi \text{ presupposes } \psi, \text{ then } \text{WANT}_a \varphi \text{ presupposes } \text{BEL}_a \psi.$$

Applied to the Karttunen example, this means that the second sentence presupposes that Sue believes that Jane used to cheat on her husband. This seems like an intuitively plausible inference. Moreover, after updating the original context with the first sentence, this information about Jane’s belief will be satisfied. Hence the presupposition of the second sentence is indeed filtered out by the first sentence, which was what we set out to derive.

In sum, Heim demonstrates how an assumption about the semantics of desire, (15), translated to a dynamic setting as (16), elegantly solves Karttunen’s puzzle about presupposition projection in *believe–desire* sequences of ascriptions.

Along the way, Heim’s paper provides a novel semantics of desire ascriptions that solves a number of non-presupposition-related problems. As a matter of fact, it is these results that have proven the most influential. With her preference-based semantics Heim paved the way for a number of recent publications in which the Hintikka-style uniform analysis of attitude ascriptions is replaced with a more fine-grained classification and semantic analysis of different attitude verbs (Villalta 2009; Anand and

⁶ Heim doesn’t discuss *hope*. Cf. Anand and Hacquard (2013) for an analysis of *hope* that combines both a preference component and a propositional one.

Hacquard 2013; Rubinstein 2012). These recent developments take the static preference ranking semantics in (15) as their point of departure for further refinements and extensions, ignoring the dynamic version and its predictions related to presupposition projection. However, like Heim I'm interested primarily in the dynamics of attitude ascriptions. The crucial difference between my analysis and Heim's is that while hers depends on the preference ranking semantics for desire, for me it's the hierarchical structure of mental state representations that accounts for the relevant projection data.

2.3.2 Three objections

Now let me point out some of the shortcomings and limitations of Heim's proposal that the current account will overcome, as well as some more general limitations that my proposal shares with Heim's.

First, as Heim herself points out, her account makes the wrong predictions for *hope–hope* sequences like (18).

- (18) John hopes that Mary will come. He hopes that SUE will come too. [cf. (8b)]

On Heim's account the presupposition of the second sentence is that John believes that someone other than Sue will come. But this is not entailed by the first sentence, so no satisfaction is predicted. As I will demonstrate in Sect. 5.4, my proposal correctly predicts presupposition satisfaction (or rather, binding, as it is called in DRT) for (18), and generally for any sequences⁷ of attitude ascriptions of a single type.

Second, Heim has great difficulty deriving the observation that presuppositions often survive attitude embedding unscathed. On Heim's proposal, *Bill hopes that it stopped raining* presupposes that Bill believes it has been raining, not that it has been raining. *De re* readings of definite description pose *prima facie* counterexamples to Heim's doxastic presuppositions:

- (19) Mary thinks that her idiot boyfriend is a genius.

The presupposition generated by Heim is that Mary believes she has an idiot boyfriend, which would be downright incompatible with the at issue content of the thought ascribed to her.

Heim tries to turn this apparent defect into a virtue by arguing that examples like (19) show the need for a mechanism of *de re* construal that is independent of presupposition projection. The literature indeed provides a wide range of such mechanisms, including intensional variables (Heim and von Stechow 2011) and syntactic *res*-movement (von Stechow and Zimmermann 2005). Heim suggests that it is this general *de re* mechanism

⁷ And, of course, conjunctions. Analogous filtering in conditionals is problematic for both Heim and my account. Consider *If Harry wants to have a son, he wants his son to be the first pianist who can play the Moonlight Sonata in less than six minutes* (Geurts 1998, p. 563). As Geurts points out, Heim's analysis suffers from the "proviso problem" here, i.e., it predicts the seemingly nonsensical presupposition that if he wants to have a son, he believes that he has one. To deal with such conditionals, my own account would need a more sophisticated "attitude merge" operation than the one I provide in Sect. 5.2, or else borrow Geurts's idea that attitude ascriptions presuppose attitude contexts. For reasons of space I restrict attention to simple discourse variants of the Karttunen puzzle.

that is responsible for the observed tendency to interpret presuppositional content as if it has projected out of the attitude in question, without the need for actual presupposition projection. The common intuition that attitude verbs are holes is thus explained as a tendency for construing presuppositional expressions *de re*.

As Geurts (1998, p. 568) rightly observes, this strategy seems to be overkill:

If presuppositions already have a natural tendency to float up from embedded positions anyway, why should they need help from a mechanism for *de re* construal? I take it that we should prefer a theory that is in a position to say that *de re* interpretations are the outcome of the standard mechanisms of presupposition projection.

I add that Romoli and Sudo (2009) have since offered a number of independent arguments in favor of the presuppositional analysis of *de re* construal that Geurts suggests,⁸ showing that such an analysis actually makes better predictions than rival accounts of the *de re/de dicto* distinction. Accordingly, in my analysis below, the mechanism of *de re* construal is fully reduced to presupposition projection, making for a more parsimonious and more empirically adequate analysis.⁹

Apart from appealing to *de re* construal Heim suggests another way to derive the intuition that presuppositions project out of attitudes: an independently plausible “spill-over” inference allows us to derive the presupposition that φ from the presupposition that someone believes that φ . Geurts (1998, pp. 588–589) questions the intuitive validity of such a general inference pattern and moreover shows that it would generate faulty predictions for a sentence like (20b).

- (20) a. John believes that it stopped raining.
b. Fred knows that John believes that it was raining.

Intuitively, (20a) presupposes that it was raining while (20b) does not. However, given that *know* presupposes the truth of its complement and *it stopped raining* presupposes that it was raining, Heim would generate the same presupposition for both, viz. that John believes that it was raining. If we then appeal to the general spill-over principle to get the desired result for (21a), why wouldn’t that apply to (20b) as well?

Summing up the second objection, Heim’s initial system generates only doxastic presuppositions and therefore needs to be supplemented with an additional mechanism to derive the observed non-doxastic one. Both of the mechanisms she considers, *de re* construal and spill-over, are ultimately unsatisfactory. In my analysis, only the simple

⁸ Geurts does not yet fully endorse a general reduction of *de re* to presupposition projection, as shown by the following passage:

the distinction between *de re* and *de dicto* readings of belief reports is to be explicated, at least partly in terms of scope. It seems to me, however, that the notions of scope and presupposition, similar though they may be, should be strictly distinguished. (Geurts 1998, p. 566)

Ergo, according to Geurts, presupposition projection is to be strictly distinguished from *de re* construal, since the latter is merely a form of scope assignment.

⁹ Cf. Maier (2011) for more on the advantages of this reduction.

non-doxastic presupposition is generated, and when it projects out of the attitude this gives rise to a *de re* interpretation.

My third and final objection to Heim's analysis concerns its limited scope. Karttunen already suggests that the phenomenon is quite general. Apart from the two verbs that Heim considers, *want* and *wish*, the asymmetric satisfaction pattern extends to many other attitude verbs¹⁰:

- (21) a. John believes that Mary will come. He {hopes/doubts/suspects/fears} that HER SISTER will come too.
 b. *John {hopes/doubts/suspects/fears} that Mary will come. He believes that HER SISTER will come too.

Arguably, the semantic interpretations of the verbs above all involve some preference or ordering component, so, we may be able to extend the original analysis. However, the phenomenon also extends to attitude verbs that clearly lack an ordering component, i.e. what [Anand and Hacquard \(2013\)](#) call purely representational attitudes:

- (22) a. John believes that Mary will come to his party. Last night he {dreamed/imagined} that HER SISTER would come too.
 b. *Last night John {dreamed/imagined} that Mary would come to his party. He believes that HER SISTER will come too.
 c. Sue thinks her boyfriend is a genius. She pretends SHE's a genius too.
 d. *Sue pretends to be a genius. She thinks HER BOYFRIEND is a genius too.

These examples are problematic for Heim because she derives Karttunen's observation directly from properties of the ordering semantics. My solution to Karttunen's puzzle does not rely on preference rankings and therefore can be straightforwardly extended to representational attitudes, as I show in Sect. 5.4.

I should point out that there are many seemingly related observations of cross-attitudinal presupposition satisfaction in the literature that neither Heim nor the current proposal will account for. First, there are some cases in which a non-doxastic attitude complement seems to bind a pronoun (a special case of presupposition resolution) originating in a doxastic or other non-doxastic attitude complement.

- (23) a. Susan wants a pet. She believes she will look after it. [[Cresswell 1990](#), cited by Heim]
 b. Alice fears that there is a squirrel in her kitchen cabinets. She hopes to trap it alive. [[Schoubye 2013](#)]

These pose a genuine challenge for both Heim's proposal and my own. Heim observes that, somehow, the second ascription in such examples gets a conditional interpretation:

¹⁰ Note that factives (*know*, *be happy*, *be unaware*, *regret*), which entail (or presuppose) the truth of their complement, don't show this asymmetry. This is because a factive in the first sentence would allow regular, global satisfaction of the *believe* embedded presupposition. In addition, ascriptions of attitudes that entail or strongly imply belief (*promise*, *say*, *be convinced that*, *remember*) may also be expected to behave symmetrically with respect to *believe*.

she believes that if she has a pet, she will look after it. A proper account of such interpretations and their relation with E-type pronouns and/or modal subordination will have to wait for another occasion.

All examples so far featured two attitudes ascribed to the same agent. This appears to be a necessary prerequisite for Karttunen-style satisfaction, as shown by the contrast in (24):

- (24) Context: Mary knows the Sue won't come. John is more optimistic.
 John believes that Sue will come. {He/*Mary} hopes that SUE'S SISTER will come too.

Heim's account, like mine, correctly predicts that John's belief cannot satisfy a presupposition triggered inside an attitude ascribed to Mary. But there are well known examples of "intentional identity", where pronouns do appear to be bound across different attitudes of different agents. Consider [Geach's \(1967\)](#) infamous Hob-Nob sentences:

- (25) Hob believes a witch blighted his cow. Nob {believes/hopes/fears/doubts} that she killed his sow.

There is no denying that there are strong similarities between this phenomenon and Karttunen's puzzle. Both involve unexpected presupposition satisfaction across multiple attitude ascriptions in a discourse. However, as the contrast in (24) shows, multi-agent satisfaction is not as generally available as Karttunen's single agent variety. I hypothesize that some additional, independent information sharing mechanisms are responsible for the Hob–Nob effect. Hence, like Heim, I restrict attention to single agent cases.

3 Representing mental states

In this section I propose a general theory of the representation of mental states. One of the central assumptions built into the proposed semantics of attitudes is an asymmetric dependence of desire and other attitudes on beliefs. Integrating the resulting theory of mental state representations into a dynamic account of presupposition resolution will then yield the solution for Karttunen's puzzle.

3.1 Modes of attitude in DRT

One of the key inspirations for the present [Kamp's \(1990\)](#), also see [Kamp et al. 2003](#)) analysis of the structure of mental representation. The leading intuition behind Kamp's proposal is that propositional attitudes are complex states consisting of entity representations and interconnected beliefs, desires, intentions and other attitudes. In this section I propose a radical simplification of Kamp's model designed specifically to capture the parasitic dependence of non-doxastic attitudes.

Concretely, say I see a cup filled with a dark substance here on the table in front of me on my desk. I believe it's coffee, and I hope it's still warm. Moreover, say, I

imagine it's whiskey, and I intend to pick up the cup and drink from it. My mental state at this point could be represented like this:

x	y	z	i	n
coffee(x)	cup(y)	desk(z)		
x in y	y on z			
x in front of i	at n			
i see x	at n			
DES-	warm(x)			
IMG-	whiskey(x)			
INT-	i pick up y			
	i drink x			

In DRT terminology, the global context in (26) represents my beliefs, in this case based primarily on my perceptual acquaintance with my surroundings. The boxes labeled DES, IMG and INT represent my desire, imagination, and intention, respectively. Other labeled boxes could represent further attitudes, like fear, doubt, dream etc. I will refer to formulas like (26) as *mental state descriptions*.

I will give the exact syntax and semantics in Sect. 3.2, but let me highlight in advance the innovation crucial to solving Karttunen's puzzle: all non-doxastic attitudes are represented as embedded inside the belief.¹¹ Given the standard DRT notion of accessibility this captures the asymmetric dependence of non-doxastic attitudes on beliefs. The dependence of desire on belief, for instance, is illustrated in (26), where the discourse referent *x* in the desire box is bound globally, in the belief box. Dependence in the other direction is not possible, discourse referents introduced inside an embedded attitude level cannot bind occurrences in the global belief representation. To illustrate this, imagine that you want to buy a new bike without having a particular one in mind. In a description of your mental state, the desired bike would be existentially introduced in the universe of the embedded subDRS describing your desire. Such an embedded discourse referent is accessible to further desires, but not to other attitudes. This means I can represent the desire that it—the desired bike—be red, but not the belief that it is better than my old one. This accessibility limitation accurately reflects a property of our mental capacities, viz. that non-doxastic attitudes are parasitic on beliefs. This will be the basis for explaining the corresponding linguistic asymmetry between belief and desire ascriptions that we observed in Sect. 2.2:

- (27) a. John believes that Mary will come. He hopes that SUE will come too.
[cf. (7)]
 b. *John hopes that Mary will come. He believes that SUE will come too.

¹¹ Note that the embedded DRSs in (26) are not embedded under a semantic operator: DES is a label, not an intensional operator. This type of complex condition, involving an embedded DRS but no embedding operator, is familiar from Hunter's DRT analysis of indexicality (cf. in particular Hunter (2014), Sect. 2.2.2).

3.2 Interpreting mental state descriptions

This section presents a model-theoretic interpretation for the mental state descriptions from Sect. 3.1. In other words, the goal is to specify under what conditions someone's mental state is accurately described by a structure like (26).

Let's start from the beginning. The general idea is as follows: to determine whether a given mental state description accurately represents a given individual's mental state we compute a semantic interpretation of the mental state description and then see if that matches the actual mental state. This presupposes that our model provides us with the mental states of individuals. But what exactly are mental states? What kind of set-theoretic objects can we plausibly add to our models for this purpose?

There's a range of possibilities on offer in the literature. On the one extreme there is Asher (1986) who assumes that mental states just *are* DRS-like syntactic structures. By contrast, Kamp et al. (2003) offer so-called "Information State Based Attitudinal States (ISBAS)", which are still highly structured but more genuinely semantic entities (in the sense of involving possible worlds and individuals rather than formulas). I adopt a simpler and more traditional view, based on the idea that an agent's beliefs correspond to a set of possible worlds (Hintikka 1962; Stalnaker 1984).

Following Lewis's (1979) analysis of *de se* belief, I'll replace possible worlds with contexts. Contexts are modeled here as triples of a world, an agent and a time: $c = \langle w_c, a_c, t_c \rangle \in C$. This means the model provides functions *Dox*, and *Bul*, mapping an agent at a world to the set of contexts compatible with what that agent there believes and desires, respectively. For ease of presentation I'll focus on these two attitudes below. Formally, a belief–desire model then looks like this: $M = \langle D, W, T, C, Dox, Bul, \mathbb{I} \rangle$ where $C \subseteq W \times D \times T$, $Dox, Bul : D \times W \rightarrow \mathcal{P}(C)$ and \mathbb{I} is an interpretation function mapping predicates to appropriate sets of semantic entities, relative to an intensional parameter.

How should we interpret a mental state description K in such a way that we can say it does or does not match an agent a 's attitudes as given by the sets $Dox(a, w)$ and $Bul(a, w)$? To answer this question I'll define both the belief-proposition expressed by K and the desire-proposition expressed by K , both as sets of contexts. But first let's rehearse the standard syntax and semantics for DRT.

Syntactically, a DRS K is a pair, $\langle U(K), Con(K) \rangle$, consisting of a "universe" of discourse referents (x, y, \dots), and a set of conditions. Conditions can be atomic ($walk(x)$) or complex ($\neg K$)—labeled conditions ($DES-K$) are not part of standard DRT and will be treated differently, see below.

The central notion of Kamp's (1981) DRT semantics is that of a verifying embedding, which is a partial function from the set of discourse referents to the model's domain D . For our current purposes we need to add an intensional parameter. Since we take doxastic and buletic alternatives to be contexts rather than possible worlds, we'll use contexts as our intensional parameter. An embedding g verifies a DRS K in c iff it verifies all conditions of K . Notation:

$$(28) \quad g \models_c K \text{ iff for all } \psi \in Con(K): g \models_c \psi.$$

Condition verification is defined by cases. For example:

- (29) a. $g \models_c P(x_1, \dots, x_n)$ iff $\langle g(x_1), \dots, g(x_n) \rangle \in \mathbb{I}_c(P)$
 b. $g \models_c \neg K'$ iff there is no $h \supseteq g$ with $Dom(h) = Dom(g) \cup U(K')$ and $h \models_c K'$.

We then say that a DRS K is true if there exists a verifying embedding g with $Dom(g) = U(K)$.

To deal with the special indexical discourse referents i and n I rely on [Kamp and Reyle's \(1993\)](#) notion of an (external) anchor. Anchors are partial embeddings intended to model Kripkean rigid designation in DRT by fixing the reference of certain discourse referents. Formally, we define truth in c relative to an anchor f that maps i and n , whenever they occur, to the context's agent and time coordinates, respectively.

- (30) $\llbracket K \rrbracket_c^f = 1$ iff there is an embedding $g \supseteq f$ such that $Dom(g) = U(K)$ and $g \models_c K$, and, moreover, $g(i) = a_c$ (if $i \in U(K)$) and $g(n) = t_c$ (if $n \in U(K)$).

By abstraction we can now trivially define also the (centered) proposition expressed by K relative to f as the set of contexts in which K is true relative to f .

- (31) $\llbracket K \rrbracket^f = \{c \in C \mid \llbracket K \rrbracket_c^f = 1\}$

As a useful shorthand we define unanchored propositions: $\llbracket K \rrbracket = \llbracket K \rrbracket^\emptyset$

To apply this basic DRT semantics to mental state descriptions we start with some additional notation to pick out the labeled subDRSs of a mental state description K . Let K_{DES} be the embedded subDRS labeled DES and K_{BEL} the global DRS of K , i.e. K minus K_{DES} . Schematically, a belief–desire mental state has the following structure:

- (32) $K = \begin{array}{|c|} \hline K_{BEL} \\ \hline DES - \begin{array}{|c|} \hline K_{DES} \\ \hline \end{array} \\ \hline \end{array}$

Let's zoom in on the belief mode first. We define the belief-proposition expressed by mental state description K as the set of contexts in which there is an unanchored verifying embedding of K_{BEL} . We then say that K captures the beliefs of an agent if its belief-proposition is true in all her doxastic alternatives:

- (33) K captures the beliefs of a in w iff $Dox(a, w) \subseteq \llbracket K_{BEL} \rrbracket$.

Before turning to desire and other attitudes, let's verify that this works with the coffee example. For ease of presentation let's consider a somewhat stripped down belief–desire version:

- (34) $K^{coffee} = \begin{array}{|c|} \hline \begin{array}{ccc} x & y & i \end{array} \\ \hline \begin{array}{cc} coffee(x) & cup(y) \end{array} \\ \hline \begin{array}{c} x \text{ in } y \\ x \text{ in front of } i \end{array} \\ \hline DES - \begin{array}{|c|} \hline warm(x) \\ \hline \end{array} \\ \hline \end{array}$

According to our semantics, K^{coffee} captures a 's beliefs in w iff for all $c \in Dox(a, w)$ there is an embedding of the universe of K^{coffee} that verifies all the global conditions in c , i.e. an embedding $g : \{x, y, i\} \rightarrow D$ with $g(i) = a_c$ and $g(x) \in \mathbb{I}_c(coffee)$, $g(y) \in \mathbb{I}_c(cup)$, $\langle g(x), g(y) \rangle \in \mathbb{I}_c(in)$, and $\langle g(x), g(i) \rangle \in \mathbb{I}_c(in\ front\ of)$. In words, K^{coffee} captures the beliefs of an agent a in w if in all doxastic alternatives c there exists a pair of individuals x and y such that x is coffee, y is a cup that contains x , and x is in front of the agent of c . This is exactly the result we should expect.

If we try to extend the semantics of belief to desire we immediately run into trouble.

(35) K captures the desires of a in w iff $Bul(a, w) \subseteq \llbracket K_{DES} \rrbracket$ [to be revised]

Consider K^{coffee}_{DES} again. Since K^{coffee}_{DES} contains a free variable x there can never be an unanchored verifying embedding of K^{coffee}_{DES} on its own. We need an anchor to fix the reference of x , but where do we get the anchor from? The idea behind our representation format was that desire is parasitic on belief, i.e., we only have desires relative to our beliefs. The x that is desired to be warm is supposed to be the coffee introduced in the belief layer, K^{coffee}_{BEL} . So somehow the anchor for interpreting K^{coffee}_{DES} should be determined by an interpretation of K^{coffee}_{BEL} . We can build this idea into our semantics by (i) introducing in the model a primitive parasitic notion of buletic alternatives, Bul^* , which gives the agent's buletic alternatives relative to a context the agent believes to inhabit, and (ii) comparing these buletic alternatives with the desire-proposition only relative to the belief contexts and embeddings that verify the global belief layer.

(36) K captures the desires of a in w iff for all $c \in Dox(a, w)$ and all f with $f \models_c K_{BEL}$, $Bul^*(a, w, c) \subseteq \llbracket K_{DES} \rrbracket^f$

The new primitive notion Bul^* , describing an agent's "belief-relative buletic alternatives", requires some explanation. It is modeled after Ninan's (2008) two-dimensional analysis of imagination.¹² The motivation for the extra context parameter is that we need our model to give us a set of buletic alternatives relative to what the agent believes. More precisely, $Bul^*(a, w, c)$ is the set of contexts compatible with what the agent a in w would desire if her belief set were the singleton $\{c\}$. Ninan provides the following intuitive heuristic for thinking about such a belief-relative attitude (I'm paraphrasing a passage from his 2008:43–44). Imagine you're agent a at w . Let c be one of your doxastic alternatives. Now imagine that c is your *only* doxastic alternative, i.e., you're convinced that you inhabit context c —free of any uncertainty. In that situation, if you consider a c' to be compatible with your desires, then $c' \in Bul^*(a, w, c)$. What (36) then does is quantify over the doxastic alternatives c and look at the buletic alternatives relative to each of those c 's. Moreover, for each c we use the verifying embedding that verifies K^{coffee}_{BEL} in c as an anchor for computing the desire-proposition.

¹² I should point out that, worried about the possibility of an agent having a *de re* attitude without any internal, uniquely identifying mental description, Ninan himself rejects this two-dimensional approach in favor of his multi-centered worlds framework. Interestingly, the rejected approach, which I adapt to my DRT framework here, has also been picked up in other work, such as Anand (2011).

Applied to the coffee example again, K^{coffee} captures a 's desires if for every doxastic alternative c and f such that $f(x)$ is an amount of coffee in c , $f(y)$ is a cup containing that coffee in c , $f(i) = a_c$, and $f(i)$ sees $f(x)$ in front of her, $Bul^*(a, w, c) \subseteq \llbracket K_{DES}^{coffee} \rrbracket^f$. That is, it has to be the case that for any f and c as above, if a 's beliefs were given by $\{c\}$, a would want $f(x)$ to be warm. This seems to capture precisely the idea that a wants the believed coffee to be warm.

Putting belief and desire together we can define when a belief–desire mental state description captures the mental state of an agent:

- (37) K captures the mental state of a in w iff
- $Dox(a, w) \subseteq \llbracket K_{BEL} \rrbracket$, and
 - for all $c \in Dox(a, w)$ and f with $f \models_c K_{BEL}$, $Bul^*(a, w, c) \subseteq \llbracket K_{DES} \rrbracket^f$

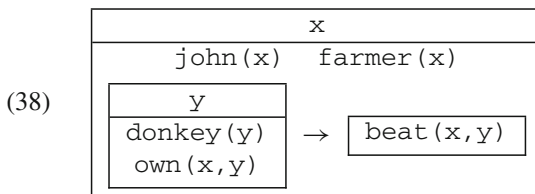
In the current section I have provided a model-theoretic interpretation for mental state descriptions. More specifically, I have defined when a belief–desire mental state description captures the actual mental state of an agent in terms of that agent's sets of doxastic and buletic alternatives as given by a model. In spelling out the details it turned out that belief played a rather different role than desire. In the eventual definition, the parasitic nature of desire that we modeled representationally as DRS embedding is also accounted for in the semantics.

The belief–desire semantics presented above can be straightforwardly extended to other non-doxastic attitudes by treating them analogously to desire as belief parasites. I will briefly return to the attitude of imagination toward the end of the paper, in Sect. 5.4, but in the meantime I will continue to focus on beliefs and desires.

4 From attitudes to ascriptions

4.1 Representing attitudes in discourse

We've used DRT to represent an agent's mental state, but of course DRT can also be used to represent the information conveyed by a discourse. The DRS below represents a context where there is a certain salient individual named John who is said to be a farmer with the property that, if he owns a donkey, he beats it.



With the framework introduced in the previous section we can represent, for instance, the mental state of John when he sees someone on TV whom he believes to be an attractive fellow farmer and whom he desires to be able to go on a date with:

$$(39) \quad \begin{array}{|c|} \hline \begin{array}{cc} z & i \end{array} \\ \hline \begin{array}{l} \text{see}(i, z) \quad \text{farmer}(z) \\ \text{attractive}(z) \\ \text{DES-} \boxed{\text{date}(i, z)} \end{array} \\ \hline \end{array}$$

Now, the fact that John has such a mental state is just another fact about John, a fact that we might want to communicate, or that might otherwise have become part of the common ground. The obvious next step is therefore to add a condition to DRT that states that someone has a certain mental state.

$$(40) \quad \begin{array}{|c|} \hline \begin{array}{cc} x & \end{array} \\ \hline \begin{array}{l} \text{john}(x) \quad \text{farmer}(x) \\ \text{Att}(x) : \begin{array}{|c|} \hline \begin{array}{cc} z & i \end{array} \\ \hline \begin{array}{l} \text{see}(i, z) \quad \text{farmer}(z) \\ \text{attractive}(z) \\ \text{DES-} \boxed{\text{date}(i, z)} \end{array} \\ \hline \end{array} \end{array} \\ \hline \end{array}$$

The semantics of *Att* is given by definition (37) above, via the following condition verification rule:

$$(41) \quad f \models_c \text{Att}(x) : K \text{ iff } K \text{ captures the mental state of } f(x) \text{ in } w_c.$$

The leading question in the remainder of the paper is now, how do we systematically arrive at representations like (40) from interpreting a given sentence in a given discourse context? The answer will make use of a presupposition theory that is designed for use with DRT. I will show that the resulting theory naturally solves the Karttunen puzzle.

4.2 Presupposition as anaphora

[Van der Sandt's \(1992\)](#) Presupposition-as-Anaphora theory accounts for the full projection behavior associated with presuppositions in a DRT framework, and is therefore ideally suited for our current purposes. A fundamental characteristic of Van der Sandt's account is that sentence interpretation proceeds in two stages. In the construction stage, a sentence is parsed and translated compositionally into a so-called preliminary DRS, i.e., an underspecified logical form, where presuppositions are represented as dashed DRS boxes. Next, in the resolution stage, this preliminary DRS is merged with a context DRS, i.e., a logical representation of the current common ground, and then the presuppositions are resolved, either by binding to an accessible antecedent, or by accommodation.

Let me illustrate this presupposition-driven dynamic account of discourse interpretation with a concrete example. Consider the following discourse, uttered in a context where farmer John is already an established topic of conversation.

$$(42) \quad \text{John bought a donkey. His wife doesn't like it.}$$

$$(43) \quad \begin{array}{|c|} \hline x \\ \hline \text{john}(x) \\ \hline \end{array} \oplus \begin{array}{|c|} \hline z \\ \hline \text{donkey}(z) \\ \text{buy}(y, z) \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \hline \end{array} = \begin{array}{|c|c|} \hline x & z \\ \hline \text{john}(x) & \text{donkey}(z) \\ \text{buy}(y, z) \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \hline \end{array}$$

	x	z
(44)	john(x)	donkey(z)
	buy(x, z)	

(45)

x	z
john(x)	donkey(z)
buy(x, z)	
<div style="border: 1px solid black; padding: 5px; margin: 5px auto; width: 80%;"> <div style="text-align: center; padding: 5px;">like(u, v)</div> <div style="display: flex; justify-content: space-around; padding: 5px;"> <div style="text-align: center;"> <div style="border: 1px dashed black; padding: 2px;">u</div> <div style="border: 1px dashed black; padding: 2px;">wife(u, w)</div> <div style="border: 1px dashed black; padding: 2px;">w</div> <div style="border: 1px dashed black; padding: 2px;">he(w)</div> </div> <div style="text-align: center;"> <div style="border: 1px dashed black; padding: 2px;">v</div> <div style="border: 1px dashed black; padding: 2px;">it(v)</div> </div> </div> </div>	

\rightsquigarrow

$w = x$
 $v = z$

 \rightsquigarrow

x	z
john(x)	donkey(z)
buy(x, z)	
<div style="border: 1px solid black; padding: 5px; margin: 5px auto; width: 80%;"> <div style="text-align: center; padding: 5px;">like(u, z)</div> <div style="display: flex; justify-content: center; padding: 5px;"> <div style="border: 1px dashed black; padding: 2px;">u</div> </div> <div style="border: 1px dashed black; padding: 2px; width: 100%;">wife(u, x)</div> </div>	

	x	z	u
(46)	john(x)	donkey(z)	wife(u, x)
		buy(x, z)	
		\neg	like(u, z)

By applying the DRT semantics of Sect. 3.2 we get the truth conditions of this DRS: (46) is true if there is someone named John who has a wife, and who bought a donkey, and, moreover, this wife of John's doesn't like that donkey.

This example should suffice as a demonstration of the construction and resolution algorithms which model dynamic utterance interpretation in the DRT framework. For more details on DRS construction and presupposition resolution I refer to [van der Sandt \(1992\)](#), [Geurts \(1999\)](#), and [Bos \(2003\)](#). Below I apply this framework to the interpretation of attitude ascriptions containing presupposition triggers.

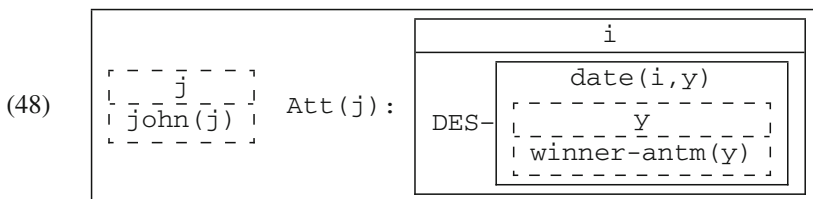
4.3 Beyond the *de re/de dicto* distinction

At the beginning of this section I introduced the *Att* predicate by which we can represent that someone has a certain mental state. Naturally we'll want to use that if we are to model the interpretation of natural language attitude ascriptions, such as those in the Karttunen puzzle. Before tackling the dependencies in a sequence of attitude ascriptions (as in that puzzle), let's consider first a single ascription.

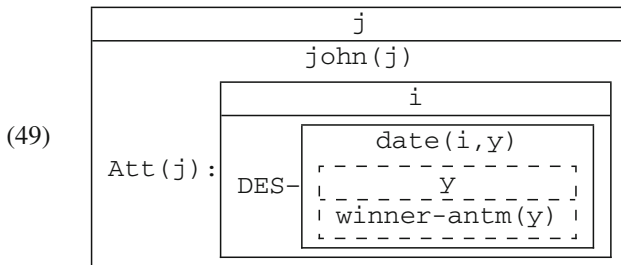
(47) John hopes to date the winner of America's Next Top Model.

This is a classic example of a report that allows both a *de dicto* (John wants to date whoever wins) and a *de re* reading (John wants to date a certain person, whom *we* characterize as the winner, regardless of whether or not he is aware of this fact about her). We'll see that the proposed combination of presupposition theory and parasitic mental state descriptions sheds new light on this classical *de re/de dicto* ambiguity.

Assume a context DRS where John is represented globally. The compositionally generated preliminary DRS representation of (47) contains two presuppositions, triggered by the definite NPs *John* and *the winner of ANTM*. I represent the *hopes that* construction as the ascription of a mental state with a global belief level representing the *de se* center (*i*), and a desire compartment representing the content of the complement clause (including the presupposition triggered therein).



Merging the context DRS with the preliminary DRS in (48) and resolving the proper name presupposition gives:

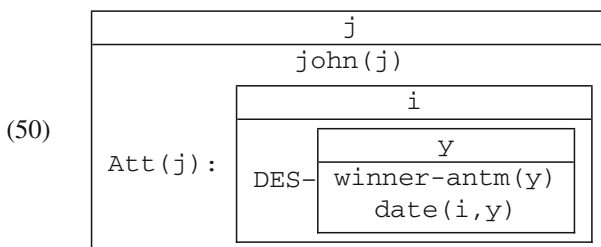


The global discourse level says that there exists someone named John who is in a certain mental state. This mental state is described as containing a representation of John's self and an attitude of desire, with the content that John himself dates the as yet unspecified winner.

In contrast to more traditional DRT analyses of belief ascriptions like my own (Maier 2010), we have not two but three levels of embedding. Given the presupposition-as-anaphora theory these constitute a projection path of three possible resolution sites for the presupposition triggered by the definite description. At none of these sites do we find a discourse referent that could plausibly bind the presupposition. So we have to consider only accommodation options. For ease of presentation I will discuss the different accommodation outputs in the order from local to global. Note however that, all things being equal, global accommodation is preferred over more local options (cf. Geurts 1999). In any case, we'll see that the combination of presupposition theory and parasitic attitudes generates three truth-conditionally distinct readings for our example. These correspond to the two traditional categories of *de dicto* and *de re*, as well as a new one in between, which, following the terminology of Yanovich (2011), we will refer to as *de credito*. To paraphrase, John wants to date the person that he believes to have won—a reading that the sentence readily allows.

4.3.1 A pure *de dicto* resolution

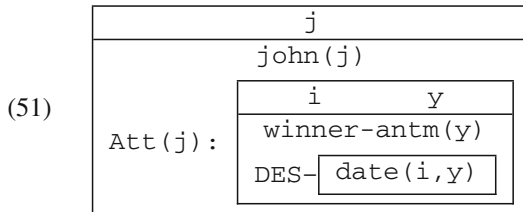
The most local resolution option for the presupposition in (49) is local accommodation, where the presupposition does not project at all but remains *in situ*, as if it were at issue content. Local accommodation is generally dispreferred, but available in the right context, especially for descriptively rich presuppositions like *the winner of America's Next Top Model*. Applied to the current example:



With our semantics of *Att*, this DRS can be shown to represent a reading where there is a contextual John, and in every belief context, the contexts compatible with what the center desires (relative to that belief context) are such that there is an ANTM winner that he dates.

4.3.2 *A de credito resolution*

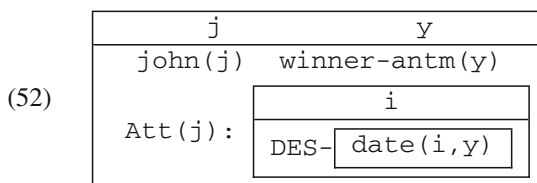
The second accommodation option puts the presupposition in the global part within the attitude representation, that is, the part where belief contents are stored.



In the resulting reading the attitude ascribed to John is not *de re*, as we assert no relation between John and any other external individual. All we are ascribing to John is (i) the belief that there exists someone who won, and (ii) the desire that he dates him or her. Since the desire referentially depends on the belief, we might call this a parasitic *de dicto* reading, or a *de credito* ascription.

4.3.3 *A de re resolution*

The next level to consider would be the global DRS, outside the attitude. Following the presuppositional analysis of the *de re/de dicto* distinction (Romoli and Sudo 2009), this should give us a *de re* reading:



Note that this simple wide scope representation of *de re* suffers from Quinean (1956) double vision problems. To fix this we could follow my (2010) presuppositional adaptation of the Kaplan (1968)/Lewis (1979) analysis of *de re* attitudes as involving acquaintance-based modes of presentation. But since the double vision issue is orthogonal to the Karttunen puzzle, I'll stick with the simple representation in (52).¹³

¹³ The central assumption of my 2010 analysis is that when a presupposition moves out of the scope of an attitude operator it triggers the introduction of an acquaintance variable inside the attitude, and an accompanying acquaintance presupposition outside of it. Adapting this procedure to the parasitic mental state framework above gives us the following intermediate representation, at the point in the resolution when *the winner* crosses the global attitude box:

In this section I incorporated the mental state descriptions from the previous section into a theory of attitude ascriptions in DRT. Applying the analysis to a simple hope ascription brought out a third reading between *de dicto* and *de re*: the *de credito*. The derivation of this reading relies on the structural analysis of hope as a parasitic attitude, distinct from, but referentially dependent on, belief.

5 Updating attitudes in discourse

We're almost ready to tackle Karttunen's puzzle, i.e., how can a belief ascription bind a presupposition triggered inside a different attitudinal embedding?

- (53) Sue thinks that Jane has been cheating on her husband. She hopes that Jane will stop cheating on him. [cf. (6)]

In this section I formulate and motivate one last piece of machinery and apply the complete theory to (53), and to some examples that were identified as problematic for Heim's alternative solution in Sect. 2.3.

5.1 Taking stock

In the previous section I've demonstrated how to interpret attitude ascriptions containing a presupposition trigger. On the basis of that mechanism we'd interpret the first sentence of (53) as ascribing to Sue a mental state in which the global belief context asserts the existence of an event of Jane cheating on her husband.

(54)

s	j	h		
sue(s)	jane(j)	husband(h, j)		
Att(s):				
<table> <tr> <td>e</td> </tr> <tr> <td>e:cheat(j, h)</td> </tr> </table>			e	e:cheat(j, h)
e				
e:cheat(j, h)				

So far this is just applying the straightforward presuppositional analysis of *de re*, as described for instance by Romoli and Sudo (2009) (cf. Sect. 4.3.3 above). The real

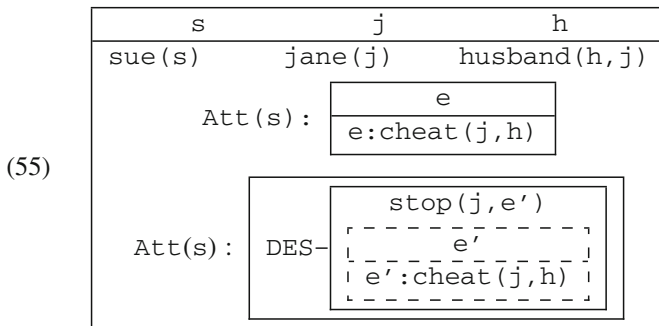
Footnote 13 continued

j								
john(j)								
<div><div>y</div><div>winner-antm(y)</div></div>	<div><div>R</div><div>R(j,y)</div></div>	Att(j):						
		<table><tr><th>i</th><th>z</th></tr><tr><td colspan="2">R(i,z)</td></tr><tr><td>DES-</td><td>date(i,z)</td></tr></table>	i	z	R(i,z)		DES-	date(i,z)
i	z							
R(i,z)								
DES-	date(i,z)							

Global accommodation of the acquaintance presupposition *R* and the *res* presupposition *y* yields an output that says there is a relation *R* and a winner *y*, and *R* holds between John and *y* and in John's doxastic alternatives there is a person he bears *R* to and whom he dates in his bulitic alternatives. I leave further discussion of the combination of acquaintance resolution and complex mental state descriptions for a future occasion.

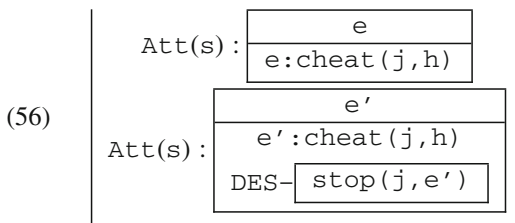
advantage of the present proposal becomes apparent only when we hit the non-doxastic attitude in the second sentence.

In the representation of the second sentence, *She hopes Jane stops cheating on him*, the mental state ascribed to Sue involves a desire compartment, so we have one extra embedding level. There are three familiar presupposition triggers (*she*, *Jane*, and *him*), which bind globally to their attitude external antecedents (Sue, Jane, and Jane's husband) represented in the context, (54). The fourth trigger, *stop cheating*, is analyzed as presupposing an event of cheating.



At this point in the derivation we are representing Sue as being in a mental state which is characterized in two separate ways: (i) she believes there's an event of Jane cheating on her husband, and (ii) she desires that Jane puts an end to the presupposed event of cheating on her husband.

The final remaining presupposition in (55), the presupposed cheating event triggered by *stop cheating*, cannot directly bind to the cheating event in the first attitude box as material inside the first attitude box is structurally inaccessible to anything in the second. However, as described in Sect. 4.3, there are in principle three accommodation options. Local accommodation/pure *de dicto* is ruled out because it entails rather implausibly that Sue wants Jane to cheat on her husband (and then also stop that cheating). Global accommodation/*de re* is ruled out because it entails that there is an actual cheating event, while all we know is that Sue *believes* that there is such an event. Intermediate accommodation/*de credito* does give a plausible interpretation for the second sentence of (53): Sue believes that there is a cheating event and hopes that it stops. Combined with the first sentence this amounts to a representation of the whole discourse in which two distinct but seemingly overlapping mental states are ascribed to Sue.¹⁴



¹⁴ Note on notation: in (56) and below I occasionally trim the contextually redundant top off DRS boxes to save space.

According to the first mental state description in (56) Sue believes that there is a cheating, and according to the second she believes that there is a cheating while hoping, relative to that belief, that it will stop.

This output is superior to what a simple analysis of attitudes as distinct intensional operators could deliver because it allows us to avoid the implausible *de re* and (pure) *de dicto* interpretations for the second sentence in favor of a much more plausible *de credito* resolution. Nonetheless, the result above doesn't quite capture the intuition that the content of the belief complement satisfies or binds a presupposition triggered in the subsequent hope complement. Rather, the second ascription is in effect interpreted independently of the first. We could derive the exact same *de credito* reading for the second sentence in isolation. This may be defensible in this particular case. Perhaps the second sentence when uttered in isolation does indeed have such a *de credito* interpretation. However, the reliance on accommodation becomes truly problematic with examples involving accommodation-resistant triggers like *too*, as discussed in Sect. 2.2:

- (57) John believes that Mary will come. He hopes that SUE will come too.
[cf. (7a)]

The current analysis could only derive the acceptability of (57) by invoking accommodation of the presupposition triggered by *too*. But by allowing accommodation in this way we would incorrectly predict that the second half of (57) would also be acceptable in isolation.

Below I smooth out this final wrinkle by proposing and motivating an extension of the DRT merge operation that essentially allows us to merge mental state descriptions along with global discourse representations.

5.2 Merging attitudes

I propose an extension of the DRS merge operation to embedded mental state representations. The idea is to treat a sequence of ascriptions of attitudes to x not just as a sequence of global updates on the common ground, but also as a sequence of updates on the complex mental state representation that is being ascribed to x .¹⁵ More precisely, I add an attitude merging operation to the DRT resolution algorithm. Resolution still starts by merging the preliminary DRS with the context DRS. Then, presupposition resolution starts. If at some point in the process of resolving presuppositions we find two attitude ascriptions to the same individual, we merge those into a single Att condition before we continue the resolution. More precisely, I propose to add the following attitude merge operation to the resolution algorithm:

¹⁵ Cf. Kamp (1990), Kamp et al. (2003) and Bary and Maier (2009) for similar proposals.

$$(58) \quad \left[\begin{array}{c} \dots \\ \text{Att}(x) : \begin{array}{c} K_{BEL} \\ \text{DES-} \boxed{K_{DES}} \end{array} \\ \dots \\ \text{Att}(x) : \begin{array}{c} K'_{BEL} \\ \text{DES-} \boxed{K'_{DES}} \end{array} \\ \dots \end{array} \right] \rightsquigarrow \left[\begin{array}{c} \dots \\ \text{Att}(x) : \begin{array}{c} K_{BEL} \oplus K'_{BEL} \\ \text{DES-} \boxed{K_{DES} \oplus K'_{DES}} \\ \dots \end{array} \end{array} \right]$$

The attitude merge operation combines the two partial representations of x 's mental state into a single more complete one. This captures the idea that a speaker can use a sequence of attitude ascriptions to dynamically represent the single complex mental state of an individual. Attitude merging opens up a range of new resolution options for attitude embedded presuppositions—precisely the ones we need for finally solving Karttunen's puzzle.

5.3 Solving Karttunen's puzzle

Now return to Karttunen's puzzle. Let's go back to (55), i.e., the point in the derivation where we had two independent attitude ascriptions to Sue, with an unresolved presupposition in the second. Instead of accommodating a new cheating inside the second mental state representation, we should first merge the two mental state descriptions, which gives (59).

$$(59) \quad \begin{array}{c} \begin{array}{ccc} s & j & h \\ \hline \text{sue}(s) & \text{jane}(j) & \text{husband}(h, j) \end{array} \\ \text{Att}(s) : \begin{array}{c} \begin{array}{c} e \\ \hline e:\text{cheat}(j, h) \\ \hline \text{stop}(j, e') \\ \hline \text{DES-} \left[\begin{array}{c} e' \\ \hline e':\text{cheat}(j, h) \end{array} \right] \end{array} \end{array} \end{array}$$

We can then trivially bind the *prima facie* problematic presupposition that Jane was cheating on her husband $e' = e$:

$$(60) \quad \left| \begin{array}{c} \text{Att}(s) : \begin{array}{c} \begin{array}{c} e \\ \hline e:\text{cheat}(j, h) \end{array} \\ \text{DES-} \boxed{\text{stop}(j, e)} \end{array} \end{array} \right|$$

The final output (60) that results from processing the two-sentence discourse in (53) correctly ascribes to Sue a mental state in which she believes of Jane that she

cheated on her husband and then hopes, relative to that belief, that she will stop that cheating.

The two innovations required to derive this solution to Karttunen's puzzle are (i) the idea that attitude ascriptions are interpreted as partial descriptions of a subject's complex mental state (which may be composed of various attitudes among which belief plays a special role); and (ii) the idea that the distinct partial descriptions of someone's mental state, as given by a sequence of attitude descriptions in a discourse, should be dynamically merged into a single more complete description of that subject's mental state.

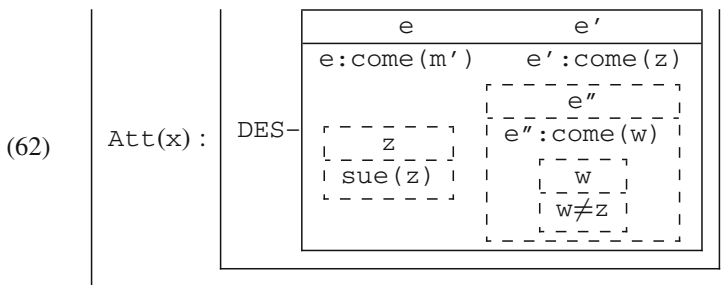
5.4 Parasitic attitudes versus Heim (1992)

In Sect. 2.3 I discussed Heim's (1992) alternative solution to Karttunen's puzzle. I identified three objections and promised that my own solution would do better. It is now time to make good on that promise.

The first objection was that Heim's analysis fails to account for cases of cross-attitudinal satisfaction in *hope–hope* sequences.

(61) John hopes that Mary will come. He hopes that SUE will come too. [cf. (8b)]

On the account proposed here we use the attitude merge operation defined in Sect. 5.2 to merge our preliminary representation of the second hope ascribed to John with the representation of the first. Hence, the information that Mary will come is accessible for the presupposition triggered by *Sue will come too*. More specifically, directly after merging the attitudes, John's desire is described as in (62), where *too* is analyzed along the lines of van der Sandt and Geurts (2001) as triggering the complex presupposition on the right (i.e., there is an event of coming e'' whose agent w is some salient individual other than the subject, Sue (z)).



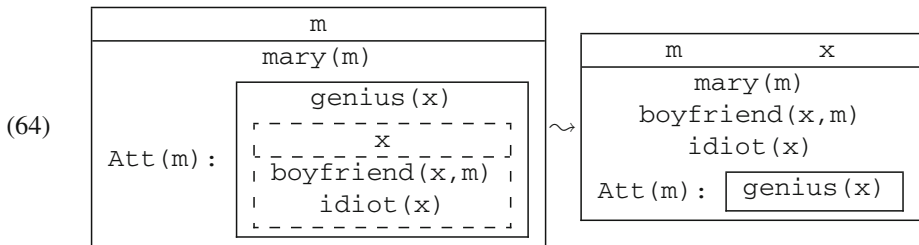
The presuppositions triggered by *too* can thus locally bind within K_{DES} : $w = m'$ and $e'' = e$, which accounts for the observation.

My second objection to Heim was that her analysis lacks an account of the intuition that presuppositions tend to escape from attitude embeddings. Without additional assumptions, her account predicts only doxastic presuppositions. This is problematic for (63):

(63) Mary thinks that her idiot boyfriend is a genius [cf. (19)]

Instead of the presupposition that Mary has an idiot boyfriend, Heim derives the unlikely presupposition that Mary thinks she has an idiot boyfriend. As argued in Sect. 2.3, the additional mechanisms that Heim suggests in order to fix this, *de re* construal and spill-over, are unconvincing.

In the current account all presuppositions “float up”. Presuppositions triggered inside an attitude embedding will therefore typically escape that embedding, unless they are bound within the attitude (as in Karttunen’s puzzle). When they do, we get a *de re* reading. For (63) this leads to the following *de re* resolution:



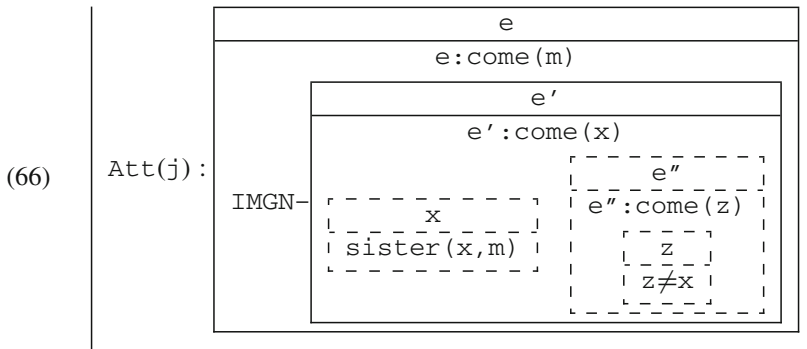
My third objection was that Heim’s solution to Karttunen’s puzzle relies on a preference ranking semantics of desire, so it cannot be straightforwardly extended to account for similar behaviors with ascriptions of representational attitudes, like *dream* or *imagine*, that don’t have a preference semantics.

- (65) John believes that Mary will come to his party. Last night he {dreamed/
imagined} that HER SISTER would come too. [cf. (22a)]

The current analysis relies on a more general aspect of the internal logical structure of mental states. As indicated in Sect. 3.1 the parasitic nature of desire extends to other non-doxastic attitudes, which immediately accounts for the kind of cross-attitudinal presupposition binding we see in (65). To make this precise we first have to add new labeled attitude representations to our mental state descriptions. I take it that just like we can have desires that are grounded in our beliefs we can also imagine or dream things about entities we merely believe to exist.¹⁶ But not the other way around: if I imagine eating ice cream I can’t strictly speaking *believe* about that figment of my imagination that it is cold. We see the same asymmetry in the linguistic domain in the contrast between (65) and the version with the attitude verbs switched, i.e., (22b) from Sect. 2.3.2. In other words, like desire, imagination and dreaming are parasitic on belief. Hence, I propose to represent these new parasitic attitudes at the same level as desires, embedded within the global belief box.

For the interpretation of (65) this means that, at the derivation stage after applying attitude merge and binding *her* to Mary (m), we have:

¹⁶ Cf. Ninan (2008), Yanovich (2011) and Anand (2011) for similar observations, in particular about imagination.



In this representation, the believed coming (e) of Mary (m) is a suitable and accessible antecedent for the presupposition triggered by *too*: $e'' = e$ and $z = m$. The proposed extension to imagination thus allows us to derive the right reading for (66).

To complete the extension we still have to say how to interpret this new mode model-theoretically. Mimicking the parasitic interpretation of desire in Sect. 3.2 gives:

$$(67) \quad K \text{ captures the imagination of } a \text{ in } w \text{ iff for all } c \in \text{Dox}(a, w) \text{ and } f \text{ with } f \models_c K_{BEL}: \text{Imgn}^*(a, w, c) \subseteq \llbracket K_{IMGN} \rrbracket^f \quad [\text{cf. (36)}]$$

For an independent motivation of the notion $\text{Imgn}^*(a, w, c)$, the set of imagination alternatives of a in w relative to c as doxastic alternative, see also Ninan's (2008) two-dimensional analysis of imagination. Further refinements, more in-depth comparisons, and similar extensions for other parasitic attitudes I leave for future research.¹⁷

6 Conclusion

This paper offers a new way of interpreting linguistic reports of attitudes other than belief. Using Karttunen's puzzle as a guiding example, I have developed an analysis

¹⁷ As suggested by an anonymous referee it might be worthwhile to explore a modification of Heim's proposal that incorporates Ninan's two-dimensional analysis to counter this third objection. That is, can we perhaps predict filtering in *believe–imagine* sequences simply by replacing Heim's preferential semantics for desire with a two-dimensional semantics for imagining in terms of Imgn^* ? Concretely, a straightforward combination of Heim and Ninan would lead to the following update rule:

$$(i) \quad C + \text{IMGN}_a \varphi = \{w \in C \mid \text{for all } c \in \text{Dox}(a, w): \text{Imgn}^*(a, w, c) \text{ satisfies } \varphi\}$$

This update rule imposes the following definedness conditions:

$$(ii) \quad C + \text{IMGN}_a \varphi \text{ is defined iff for all } w \in C, c \in \text{Dox}(a, w): \text{Imgn}^*(a, w, c) + \varphi \text{ is defined.}$$

From this we can derive the following projection behavior:

$$(iii) \quad \text{if } \varphi \text{ presupposes } \psi, \text{ then 'John imagines that } \varphi \text{' presupposes that John imagines, relative to all his belief worlds, that } \psi.$$

This predicts filtering in *imagine–imagine* sequences, but fails to capture the crucial Karttunen-style filtering that can be observed in *believe–imagine* sequences like (65).

in which a sequence of multiple attitude ascriptions can be seen as incrementally providing a representation of someone's complex mental state.

My account starts with an analysis of the structure and interpretation of mental states. From [Kamp \(1990\)](#) I take the DRT framework as a way to represent mental states as consisting of different, interrelated attitude compartments. From [Asher \(1987\)](#), [Heim \(1992\)](#), [Maier \(2006\)](#), [Ninan \(2008\)](#), and [Yanovich \(2011\)](#) I take the insight that non-doxastic attitudes are asymmetrically dependent on belief. Accordingly, I represent an agent's beliefs as a global DRS context in which all other attitudes are embedded. In spelling out the model-theoretic interpretation of the resulting mental state descriptions, I incorporate a specific semantics designed for parasitic imagination by Ninan.

With the representation and interpretation of mental states in place, the next step is to incorporate it in a semantics for attitude ascriptions in natural language. Here, I take as a point of departure the presuppositional analysis of belief reports as defended by [Geurts \(1998\)](#), [Romoli and Sudo \(2009\)](#), and [Maier \(2010\)](#). Combining this with the complex mental state descriptions leads us to redraw the *de re/de dicto* distinction: For ascriptions of attitudes other than belief there arises a parasitic or *de credito* reading, between the classic *de re* and *de dicto*.

As a last step on the way to solving Karttunen's puzzle I turn to the dynamics of attitude ascriptions. Karttunen's example shows not only that desire ascription is parasitic on belief ascription, but also that a sequence of attitude reports may be used to ascribe a single complex mental state to a subject, rather than just to ascribe a series of independent attitudes. I incorporated this dynamic aspect of attitude ascriptions into the presupposition resolution algorithm in the form of an attitude merging operation.

The paper shows that Karttunen's puzzle disappears once we recognize (i) the parasitic nature of desire and other non-doxastic attitudes, and (ii) the dynamics of attitude reports. Moreover, it shows explicitly how to incorporate these insights into a fully general, conservative, and explicit semantics of attitude ascriptions in discourse.

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